CANADIAN OCCUPATIONAL PROJECTION SYSTEM

THE EFFECTS OF TECHNOLOGICAL CHANGE ON EMPLOYMENT OF ENGINEERING AND APPLIED SCIENCE TECHNICIANS AND TECHNOLOGISTS IN CANADA AND MANITOBA

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APRIL, 1987

WH-3-668E

90-00689/

This report was prepared by Dalcor Innoventures Ltd. of Edmonton for the Labour Market Outlook and Structural Analysis Branch of Employment and Immigration Canada (E.I.C.) in Ottawa. The opinions expressed are those of Dalcor and do not necessarily reflect those of the Branch, E.I.C. or of the Government of Canada.

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1. INTRODUCTION

Employment and Immigration Canada has completed joint agreements with many occupational groups across Canada. In 1984, agreements were signed with the Canadian Council of Technicians and Technologists (CCTT) and the Manitoba Society of Certified Engineering Technicians and Technologists (MANSCETT). One of the activities identified as part of the agreement was a Data Development Project regarding certified engineering technicians and technologists in Manitoba.

CCTT constituent societies register and certify members in engineering and applied sciences technology. The term "engineering technicians and technologists" is used throughout the report to cover both engineering and applied science technicians and technologists.

The registration of engineering technicians and technologists with MANSCETT is voluntary. This means that the MANSCETT membership is only a portion of the total working population. In addition, employers do not necessarily define technicians and technologists in the same way as MANSCETT. In dealings with employers, we have tried to ensure that we interviewed personnel who work with engineering technologists and technicians on a daily basis and thereby avoid misinterpretation.

The MANSCETT Data Development Project is a pilot project based in Manitoba aimed at improving the understanding of the role and supply of and demand for engineering technicians and technologists. The results of the pilot project will facilitate further development, by CCTT and its constituent provincial associations, of a framework for a comprehensive national database on Canada's technicians and technologists. The project involves the development of a computer database including occupational and employment data and a survey of the membership to gather information which can be loaded into the database for analysis. The results of this part of the project are reported in a separate document.

A second objective of the study is to assess technological change as it affects members and potential members of MANSCETT and CCTT. However, this portion of the project is intended only as a limited look reflecting the $ 2750 budget allocated. As such, many peripheral and related issues which deserve attention have been left for other researchers. The work IS NOT a comprehensive treatise on technological change. It IS a sampling of views expressed by employers and the literature.

This report presents the findings arising from that work. It considers the effects of data processing and other electronic equipment on current and future levels of employment and reports the views of employers, educators and government in Sections 2 through 4 and summarizes the findings in Section 5.

2. TRADITIONAL SOURCES OF EMPLOYMENT IN CANADA AND IN MANITOBA

2.1 Evolution of the Engineering Team

Who qualifies as an engineering technician or technologist? The Canadian Council of Technicians and Technologists publishes profiles which state:

> "A Certified Engineering Technologist or Applied Science Technologist is a professional who, through academic training and experience in the application of mathematics and engineering or scientific principles, is capable of assuming responsibility and of exercising judgement in the field of engineering or applied science technology in which training has been achieved."

> "A Certified Engineering Technician or Certified Technician is an individual who, through academic training and experience in the application of mathematics and engineering or scientific principles, is capable of accepting responsibility and of exercising judgement in the specialized portion of the field of engineering or applied science technology in which training has been achieved."

An engineering technologist is defined in the Canadian Classification and Dictionary of Occupations (1971) as:

> "...primarily in support of engineering research, development and design activities, using knowledge of engineering, scientific, mathematical and drafting design principles and practises,...."

For occupational purposes such as the Census and Labour Force Survey, the definitions of CCTT are reasonably close to those of Statistics Canada. Employers' definitions range across a much wider scale. Thus, we find situations including:

- positions filled by technicians and technologists where certification IS NOT required.
- positions filled by technicians and technologists where certification IS required.
- positions filled by non-technically trained people where technical and scientific training WOULD BE AN ASSET.

Part of the reason for the variation is that engineering technicians and technologists as distinct occupations are a relatively new phenomenon in Canada. Until the early 1960's, with the exception of Quebec, there was no formal recognition of these occupations. Jobs such as engineering assistant, surveyor's helper and draftsman did exist, but their scope was limited. Typically, persons who filled these positions had vocational training or perhaps on-the-job experience. Most design and synthesis activities were carried out by engineers.

The early 1960's saw a growing appreciation of the role for engineering technicians and technologists as an integral part of the engineering team. The benefits from workers who could take on increasing amounts of analytical work were apparent. At the same time, as the work itself became more complex, the advantages of a team approach began to be noticed. Although there were no defined relationships, engineering technicians and technologists tended to work more closely with engineers than with tradespeople.

Immigrants trained in European institutions brought skills unlike those available from Canadian workers. The nature and benefits of their training were observed. The federal government instituted a program to develop "technical" schools based to some extent on the European model across Canada. By the late 1960's, such facilities were in operation in all Canadian provinces except for Nova Scotia which retained a more traditional system.

At about the same time, engineering technicians and technologists began to develop a stronger sense of identity. Societies were formed in each of the provinces to tighten the bonds and formalize standards within the group. During this phase, the engineering associations worked closely with the new societies.

The societies grew and prospered and established role statements for the work carried out by their members. Certification Boards developed more rigid standards setting out the basis for membership. The level of responsibility assumed increased steadily. Standards meant more confidence was given to the work of technicians and technologists. More autonomy was offered as a result, although engineers remained legally responsible. Some of the societies in Canada moved to have their role recognized by provincial statute. At this time, five provinces incorporate technicians and technologists in statutes; New Brunswick, Quebec, Ontario, Alberta and British Columbia.

As the complexity of production facilities increased, so too did the level of expertise required to operate them efficently. In production plants, engineering technicians and technologists began to be hired in preference to lesser skilled operators. Employment increased at the expense of tradesmen and lesser skilled plant operators.

The role and responsibility increases led to technicians and technologists taking on work previously assumed by engineers. The result is an "applied science/engineering team" which has certainly established a healthy level of respect between its members and is more capable than at any time in the past.

2.2 Current Relationships of Employment to Economic Activity in Canada and in Manitoba

Detailed data relating industry of employment with occupation are currently available from unpublished Census data only. However, even these data are limited. This is one of the reasons why the data development project can potentially be of such great value. It will provide a set of relationships in much greater detail than has ever been available in the past. These data can then be used to facilitate human resource planning and improve the relationships between industry and MANSCETT.

1981 Census data for technician and technologist occupations for all Canada are presented in Table I.

TABLE. I

RELATIONSHIP OF EMPLOYMENT TO GROSS DOMESTIC PRODUCT (GDP) IN CANADA

OCCUPATION	1981 Census Persons	HOURS WORKED @ 1740 hrs '000s	GDP 1981 $ billion	HOURS WORKED per $ million
Supervisors	8,050	14,007	355.994	39.3
Surveyors	17,605	30,633		86.0
Draftspersons	42,990	74,803		210.1
Eng Technicians & Technologists	47,855	83,320		234.0
Other Eng & Arch Occupations NES	5,005	8,709		24.5
TOTAL	121,505	211,472		594.0

Source: Census, Statistics Canada Cat. 13-001 and DALCOR estimates
Note: NES means "not elsewhere specified"

The figures show that the total population in Canada is 121,505 persons in occupations generally eligible for certification as engineering technicians and technologists. Using the GDP together with the Census estimates for 1981 employment by occupation, DALCOR has calculated the ratio of employment to GDP in terms of hours worked per $ million (1981), (Table I). Higher ratios indicate more employment is created by a given amount of economic activity. The engineering technicians and technologists have the most sensitivity to changes in the level of economic activity. It takes only $4,274 of GDP to generate 1 hour of work for an engineering technician or technologist. This compares to $11,628 for a surveyor and $25,445 for a supervisor.

Data on the numbers of experienced persons in the labour force in Manitoba who fall within the 216 series of occupations are shown in Table II. These data have been obtained from unpublished 1981 Census results.

As with the data for Canada, the relationship of employment to economic activity for Manitoba is shown in terms of hours worked per $ million (1981) for each of the occupations. The data are similar to those for Canada as a whole, but the employment generated in Manitoba is marginally less than that generated in Canada for the same level of activity. For example, it takes $4,448 to generate 1 hour of work for an engineering technician or technologist in Manitoba, $10,215 for 1 hour of a surveyor and $30,864 for a supervisor.

TABLE II

RELATIONSHIP OF EMPLOYMENT TO GROSS DOMESTIC PRODUCT (GDP) IN MANITOB

OCCUPATION	1981 Census Persons	HOURS WORKED @ 1740 hrs	GDP 1981 $ billion	HOURS WORKED per $ million
Supervisors	255	426,300	13.158	32.4
Surveyors	745	1,287,600		97.9
Draftspersons	1,360	2,340,300		177.9
Eng Technicians & Technologists	1,770	2,958,000		224.8
Other Eng & Arch Occupations NES	220	374,100		28.4
TOTAL	4,350	7,386,300		561.4

Source: Census, Statistics Canada Cat. 13-001 and DALCOR estimates
Note: NES means "not elsewhere specified

DALCOR has projected these results to 1986 and disaggregated the total number of technicians and technologists resident in Manitoba into MANSCETT members and non-members. Estimates of employment by industry and by occupation are shown in Tables III and IV. The basis for these estimates is described in the Occupational Inventory Report.

TABLE III

MANSCETT MEMBERS AND NON-MEMBERS by INDUSTRY of EMPLOYMENT

INDUSTRY	1986 Est Total	MANSCETT Members	MANSCETT Non-Members
Resources	168	90	78
Manufacturing	1,068	334	734
Construction	456	119	337
Trans/Util	1,146	256	890
Services	1,350	326	1,024
Public Admin	1,032	343	689
TOTAL	5,220	1,468	3,752

Source: DALCOR estimates

TABLE IV
MANSCETT MEMBERS AND NON-MEMBERS by OCCUPATION of EMPLOYMENT

OCCUPATION	1986 Est Total	MANSCETT Members	MANSCETT Non-Members
Supervisors	305	285	20
Surveyors	893	7	886
Draftspersons	1,630	49	1,581
Eng Technicians & Technologists	2,122	1,115	1,007
Other Eng & Arch Occupations NES	270	12	258
TOTAL	5,220	1,468	3,752

Source: Dalcor estimates

Technology education programs have been offered in Manitoba since 1965. Enrolments in recent years range from about 600 to 700 persons. There are about 170 to 300 graduates per year. Assuming that all graduates remain in Manitoba and that there is no inflow from elsewhere, one can infer that there is a potential supply of 5,000 to 6,000 graduates. There are also people "doing" technology who entered the workforce before training was available from a recognized institution. Most of these individuals are 40 years of age or older.

A comprehensive survey of employers could be used to determine the number of engineering technicians and technologists in the workforce. The scope of this study did not permit such a survey. However, DALCOR did interview a number of major technical employers in Manitoba to gain a general appreciation of the situation.

Major employers were the major source of information because they were felt to offer the best overview of the situation. However, it is acknowledged that smaller employers may also be at the centre of innovative trends.

Both government and private sector organizations were interviewed. Reported technical employment for the firms surveyed is in excess of 1,400 persons in technician and technologist positions. This is approximately two thirds of the projected employment in Manitoba for these occupations.

2.3 Current Supply and Demand - balances & imbalances

At present, the most comprehensive demand projections are those developed by COPS on behalf of Employment and Immigration Canada. The COPS 1986 reference case for Canada is presented in Table V.

TABLE V

COPS 1986 REFERENCE CASE (CANADA) - OCCUPATIONAL DEMANDS

(persons)

OCCUPATION	SUPPLY Census 1981	DEMANDS 1986	1989	1992	% INCR 86-92
Supervisor	8,050	7,624	8,151	8,475	11.2
Surveyors	17,605	22,803	25,117	26,360	15.6
Draftspersons	42,990	49,440	53,240	55,146	11.5
Eng Technicians & Technologists	47,855	55,355	58,638	60,032	8.4
Other Eng & Arch NES	5,005	6,105	6,595	6,905	13.1
TOTAL	121,505	141,328	151,742	156,918	11.0

Source: COPS Projections - Employment and Immigration Canada.
1981 Census - Statistics Canada

These data show growth rates of approximately 11 percent over the next 7 years. Highest growth rates are for surveyors. Lowest rates are for technicians and technologists.

These data are generated by a fixed coefficient model which multiplies a coefficient by industry output. The coefficients are essentially productivity figures (hours/$ industry output). This paper is exploring changes in productivity, so the COPS fixed coefficient projections are, by their very nature an inappropriate measure.

Employment and Immigration Canada also publishes occupational outlooks from time to time. These outlooks are more braodly based and intended to consider changes which are occurring in the labour market. The 1986 edition of Job Futures states (12):

Surveyors — "This occupation is currently facing labour market conditions that are not very favourable as indicated by its higher than average claims rate. This occupational group is highly sensitive to construction activity."

Drafting — "New technology has eliminated repetitive tasks. There is a general upscaling of this occupation. The occupation may be highly sensitive to changing economic conditions."

Technicians/Technologists — "Widespread application of technology and miniaturization will benefit this occupational group, especially the electrical, electronic, industrial and mechanical engineering disciplines."

Unemployment claimant data for Canada for the period 1985/86 are presented on Table VI. These data show unemployment dropping in most of the occupations in Canada over the last 2 years suggesting an improving job market. However, the level remains in excess of 10 percent (based on 1986 projected demands) and is highest among surveyors (14.4%) and engineering technicians and technologists (12.9%). Drafting shows a lower level (8.4%) and supervisors the lowest of all (2.8%).

TABLE VI
CANADA - CENSUS & UNEMPLOYMENT LEVELS

Occupation	Census	UI Claimants							
	1981	1Q85	2Q85	3Q85	4Q85	1Q86	2Q86	3Q86	4Q86
Supervisors	8,050	285	220	190	197	231	279	256	216
Surveyors	17,605	4484	3152	2543	3053	4106	3340	2741	3287
Drafting	42,990	5064	4379	3939	3953	4133	4321	4100	4181
Technologists	47,855	8859	7497	6622	7079	8141	7341	6748	7163
Oth 216 NES	5,005	777	769	743	755	850	899	810	797
TOTAL	121,505	19469	16017	14037	15037	17461	16180	14655	15644

Source: CANADA CENSUS and COPS-Employment & Immigration Canada.

The COPS reference case for Manitoba is presented in Table VII. The data show growth rates of approximately 21 percent over the 7 year projection period, nearly twice as high as for Canada as a whole. However, the reader is reminded again that they are fixed coefficient projections and not particularly meaningful in a study of technological change.

TABLE VII
COPS 1986 REFERENCE CASE (MANITOBA) - OCCUPATIONAL DEMANDS
(persons)

OCCUPATION	SUPPLY	DEMANDS			% INCR
	1986	1986	1989	1992	86-92
Supervisor	305	255	277	294	15.3
Surveyors	893	953	1,120	1,216	27.6
Draftspersons	1,630	1,556	1,757	1,897	21.9
Eng Technicians & Technologists	2,122	1,918	2,101	2,257	17.7
Other Eng & Arch NES	270	254	288	307	20.9
TOTAL	5,220	4,935	5,543	5,971	21.0

Source: COPS Projections - Employment and Immigration Canada.
Supply Estimates - DALCOR

Table VIII shows unemployment data by occupation for Manitoba over the past two years. From these data, we see that there is currently a modest oversupply among engineering technician and technologist occupations in Manitoba. Unemployment rates in Manitoba are significantly less than for Canada as a whole, especially among technicians and technologists.

TABLE VIII
MANITOBA - CENSUS & UNEMPLOYMENT LEVELS

Occupation	Census	UI Claimants							
	1981	1Q85	2Q85	3Q85	4Q85	1Q86	2Q86	3Q86	4Q86
Supervisors	255	4	4	6	9	7	5	7	3
Surveyors	745	111	57	38	80	100	60	41	116
Drafting	1,360	129	88	71	77	78	65	71	78
Technologists	1,770	115	96	79	88	98	93	154	129
Oth 216 NES	220	26	25	28	31	22	27	27	30
TOTAL	4,350	385	270	222	285	305	250	300	356

Source: CANADA CENSUS and COPS- Employment & Immigration Canada.

All persons interviewed stated that there is currently no problem obtaining engineering technicians and technologists. This is true for all business sectors surveyed.

Red River College indicates that graduates generally obtain employment, but often look to industries such as printing, agriculture and photography which have not previously employed college graduates. This could indicate that traditional sources of employment are saturated, but also that the value of the training received is more wide ranging than might be apparent at first glance. It also suggests that more sophisticated technology is now used in industries where it was not previously utilized.

Most employers, except those in manufacturing, report that the current levels of employment will likely remain more or less constant. Manufacturers note that the level of employment will grow, largely through displacement of lesser skilled equipment operators and maintenance staff. Growth will also occur as technologists continue to find employment in industries which had not previously employed them at all.

Traditional sources of employment mentioned during the interviews are:

Engineering and Architectural Positions
Draftspersons
Surveyors
Production operations
Maintenance
Quality Assurance and Testing

Emerging employment opportunities which were specifically identified are expected to be found in:

Numerically controlled machinery programming
Production plant supervision
Plant maintenance (especially electronic controls)

3.0 COMPENDIUM OF VIEWS ON THE IMPACT OF COMPUTERS AND DATA PROCESSING ON EMPLOYMENT IN CANADA AND MANITOBA

It is impossible to undertake a meaningful survey of the effects of micro-electronics on technical employment during the course of a single week. Therefore, the assessment is limited to a quick survey and presentation of anecdotal evidence. Work underway at the time of our survey and published subsequently will provide a more comprehensive and reliable base of research evidence. Our approach is to cite anecdotal evidence as presented to us by interview respondents and couple this evidence with recently published literature.

3.1 Current "EDP" Applications

It is only about 25 years since computers began to find their way into business. Initially, highly trained experts were required and the computers themselves were bulky, required carefully maintained operating environments and were too expensive to use except for complex applications within large organizations. Applications tended to be in accounting and analytical work with limited effect on the shop floor.

During the 1970's, technology improved greatly. Machine size was rapidly reduced and operation became much more oriented towards the user. Computer controlled machinery and equipment became common in factories and process facilities and access to computing power for analytical purposes bacame available to any potential user.

In the 1980's, computing power continued to grow while prices fell. The machines became more durable and required less stringent environmental control. Now, most technically trained personnel either own or have regular access to computing power. Computers have become just another tool in the same way as the slide rule, calculator, electric motor or machine. Three major applications stand out. These are as calculating machines, data base managers and production control tools. Virtually all users or their organizations prepare reports and presentations using computers.

Manitoba Hydro employs computers to simulate their distribution system so that new transmission systems will meet specified standards of reliability and performance. A complex mathematical model is developed on the computer, and various demand load scenarios imposed to determine the impact on possible transmission schemes. Engineering consultants use computers for design calculations and to prepare engineering drawings.

Manitoba Environment uses computers to maintain information on water and effluent quality at numerous locations throughout the province.

Bristol Aerospace employs numerically controlled machine tools to improve output rates and tolerances.

Other users identify a host of similar applications.

3.2 Views on Productivity and Employment Trends

Productivity typically means the level of output per hour worked. Output is generally measured in terms of dollars. Yet, the output from a "knowledge-based" worker may be hard to measure. Is it hours of work, number of drawings, calculations made or units built? Certainly work using computers is more comprehensive now, more options are assessed and designs tend to be closer to the optimum. The total hours worked have not apparently changed very much, but better results are delivered. Where human judgement is involved, productivity gains become intangible, but the increased quality and thoroughness associated with the results generated through computers is more evident.

Jecchinis in a study for the Ontario Manpower Commission submitted in 1980 (10), outlined the debate over the effects of EDP on employment. He noted that some authors forecast substantial job losses from micro-electronics while others demonstrate net gains or at least maintenance of jobs that would otherwise be lost. However, he also pointed out that virtually all agree that the demand for scientists, technologists and engineers will increase.

The Building Tomorrow Conference in Toronto in November, 1986 offered some insights. Productivity gains of 2 to 1 or 3 to 1 were quoted for repetitive production of drawings and for alterations to drawings. A gain of 3.61 was reported by an engineering firm and 2.2 by an architectural firm producing 300 plots per month. A draftsperson who used to do stair detail can now handle a multi-million dollar building. At the same time, speakers pointed out that one-off drawings on CAD systems yield negative productivity. The real gains are for repetitive work, especially items with very little innovation involved.

There is broad agreement that EDP systems allow users to do more than in the past. However, there is far less consensus on whether they increase productivity or economic value added. The expense involved to implement systems requires twofold or threefold gains in output to break even according to speakers at the Building Tomorrow Conference held in Toronto in late 1986. These gains are being achieved, but are not available except for repetitive or complex activities.

The Canada Employment and Immigration Advisory Council reported in a report to the Minister in 1982 (5) that there will be gaps created by the increased need for highly skilled occupations such as technologists. They went on to report "that some job displacements will occur, and that they will primarily affect the tertiary sector, and that those most affected will be the non-skilled and semi-skilled workers."

The Ontario Manpower Commission (6) in 1981 noted the micro-electronics industry employed less than 3 percent of the technicians and technologists in Ontario in 1981. They estimated that an additional 1,500 technicians and technologists would be required for the industry over the 1981-85 period, about 30 percent of the supply available from Ontario Community Colleges over the same period. They expected the supply to fall short of requirements.

The Report of the Automotive Industry Human Resources Task Force was presented in November 1985 (8). It presents a discussion of the effects of new technologies on the industry. It is a useful guide for those considering the directions and impacts of technological change in North America.

The Automotive sector report differentiates between soft and hard technology. Soft technological change occurs when styles of production management and operation are changed. Essentially they deal with the way people use existing equipment. Hard technological change actually involves the plant, machinery and equipment which are used.

Shifts in equipment used in manufacturing are occurring very rapidly and will likely continue for some years to come. Numerically controlled machines (CNC) are becoming common as are programmable controllers. The Task Force points out that 36 percent of automotive metal machining companies had introduced CNC technology as of 1985, but that 68 percent expected to have it in place by 1990. At this rate, virtually 100 percent of the firms would be using the technology by 1995. The effect is to increase the demand for people skilled in CNC machine repair and maintenance over the next 10 years.

The Automotive report also addresses Computer Aided Design (CAD).

> "CAD itself has had little effect on the workforce at large. Among assemblers (companies), CAD has decreased the need for draftspeople .... " (p.82)
>
> "the fantastic sophistication of programming required to drive computer-integrated manufacturing and self-diagnostics is now emerging from the laboratories. Complicated communication technologies will become increasingly routine." (p.85)

The report notes further that new manufacturing technology results in a change in worker skills requirements from operation to monitoring. This involves analytical work, a whole new skill set, and probably explains why some employers interviewed in Manitoba report that machine tool operators are being replaced by engineering technicians and technologists.

Employers responding to surveys such as that of the Ontario Manpower Survey (6) project a rapid increase in demand for engineering technologists. Projected changes over the 1981 to 1985 period are shown below:

EMPLOYMENT IN TECHNICAL OCCUPATIONS
Micro-electronics and Related Manufacturing
Ontario Industry Survey

OCCUPATION	Employees Mar 81	PERCENT CHANGE 1981 - 85
Electronic Technologists	101	161.1
Mechanical Technologists	20	120.0
Electronic Technicians	124	134.7
Mechanical Technicians	12	83.3
Electro-mech Draft Technicians	54	112.5

Source: Ontario Manpower Commission (6)

While one could conclude from the above that serious labour market adjustments are taking place, they are placed in perspective by a recent study published by Statistics Canada. Picot (11) in a review of the changing Canadian industrial job mix over the 1951 to 1984 period observes,

> "It is also important to remember in discussions of the industrial restructuring that it is always going on, and has always gone on. One analyst estimates that two-thirds of the jobs that existed in industrial nations a hundred years ago have been 'eliminated', but three times as many people are at work."

In the end, the situation remains contentious. There is no agreement as to the net benefits which will arise, but there is clear agreement that the skills required from employees will change.

3.3 Views of Employers

DALCOR interviewed 16 major employers representing a cross-section of industries in Manitoba. The organizations are listed in APPENDIX A together with the name of the contact interviewed. Six of the firms were also visited for face-to-face follow up discussions. Collectively, these firms employ more than 1,500 technicians and technologists in Manitoba.

The firms interviewed are broadly representative of activity in Manitoba. Smaller firms were not interviewed due to time constraints, so their views are not included.

One of those interviewed sees a growing role for technicians and technologists. His view is that technologists move into the management field fairly quickly, especially in manufacturing plant environments where expertise in facility layout, work station management and costing and estimating is critical.

Employers are not trying to turn other non-technical staff into capable technical people. They hire qualified staff and supplement their training in accordance with corporate needs. From this point of view, graduates from technical institutes and community colleges fill most new openings.

Certification was discussed in each personal interview. Generally, it does not affect employment. Among those interviewed, only the City of Winnipeg and Manitoba Hydro indicated that they require certification as a pre-requisite for specified positions. All other respondents acknowledge that certification is an asset, but is only formally considered "when all other things are equal".

All those interviewed see a growing role for EDP in the form of simulation modelling, CNC machinery, information management, remote sensing and data acquisition, CAD/CAM and general management activities. Most of the organizations have invested from $10,000 to $50,000 or more per capita (among technical personnel) in micro-electronics based equipment over the last few years.

The gains in productivity from these applications vary. In general respondents note that there is as much to gain from management methods as from automation. When one looks at specific CNC machines, gains of 400 to 500 percent are possible. However, in practise, 50 to 100 percent is achieved. Obtaining the rest of the potential is a management challenge.

In the knowledge area, benefits are more difficult to measure. Most respondents suggest that there are no hard gains achieved, but the outputs are better than before. This means that final designs are "better" but may not be achieved any faster. Instead, more options are considered and a more optimal solution should result leading to reduced cost in the end. Measured in terms of hours of work, however, no change is apparent. Yet, organizations also realize that investment in EDP is necessary if they are to remain competitive.

Training is a concern of all respondents. All note the benefits of increased training in computers, mathematics and basic scientific skills. They note that too many managers lack technical training. In terms of engineering technicians and technologists, most respondents are satisfied with the level and nature of formal education and training received.

None of the employers expressed particular concern about shortages of technically trained personnel. Some pointed out that specific direct skills may be lacking, but that there is an adequate pool of people with related skills who can be readily adapted to employer needs.

3.4 Views of Government

Governments tend to be slow in adopting EDP methods. They are having the most difficulty moving from a main-frame environment to a micro-electronic world. This leads to a relatively slow take-up of new technology and a slower evolution towards new job skills. Current efforts are primarily in the area of management information and database systems. Most of the innovative uses of EDP by government are contracted out.

As a result, governments are still producing larger amounts of paper than the private sector. During the next few years, governments do expect to increase their investment in electronic equipment. Most applications will be related to information. As such, there is unlikely to be a significant impact on employment. Clearly, however, engineering technicians and technologists are better equipped for the world of the future than many of the current staff.

Manitoba is applying technology to remote sensing and monitoring in addition to data processing applications. This reduces the requirements for field staff to carry out on-site activities and has upgraded the work which is being done. Job opportunities for technically trained personnel are increased as a result.

Both the federal and provincial governments are under pressure to become more efficient and to make do with reduced levels of human resources. Government respondents state that there are few job openings at the present time, but when they arise, many qualified candidates come forward.

3.5 Experience Elsewhere

The Ontario Manpower Commission (6) reported that firms involved with the manufacture of electronic components, communications equipment, computing equipment and scientific equipment increased the level of employment more than twofold over the period from 1976 to 1981. "Technicians increased their share of total employment significantly, as more and more technicians are required for service and quality control."

In another study, The Ontario Manpower Commission considered the demands for process piping designers and draftspersons(9). This group includes mechanical technologists and technicians and draftspersons. The study considered the effects of computers in piping design. The use of computer drafting equipment among larger firms was found to be already high with about 30 percent of firms using such equipment. The impact is concentrated on drafting employment where the study notes that "one computer terminal and one operator can replace up to four piping draftspersons". The study concluded that jobs for piping designers would not be affected unless computers could do piping design. The implication was that they could not. The study finally notes that the cyclical nature of the design industry makes it impossible to project shortages accurately in any case.

4. IMPLICATIONS FOR FUTURE EMPLOYMENT IN CANADA AND MANITOBA

4.1 Current Trends

Manitoba represents a mixed economy and is generally considered a microcosm of Canada as a whole. However mining, forestry, manufacturing, construction, utilities and the public sectors are especially important.

A recent COPS study of the Metal Mining Industry (7) noted that major changes have occurred in the employment of engineering technologists and technicians. These occupations have increased dramatically from 0.8 percent of the workforce in 1981 to 2.3 percent of the workforce in 1985. During the same period, the total mining industry workforce declined from approximately 69,000 to 51,000 workers. Thus, the employment of technicians and technologists has moved against overall industry trends, increasing from about 550 workers to about 1350 workers, an increase of about 250 percent over four years. There is a strong trend to more automated mining in Canada, which will tend to support a continuing increase in employment levels for technicians and technologists in this sector.

In manufacturing, the use of technicians and technologists is growing at the expense of medium skilled vocational workers. Manufacturers report that while total employment remains constant, the complex demands associated with CAD/CAM have led to the need for engineering technicians and technologists.

The consensus is that computers in ALL fields will increase the demands for technicians and technologists. Design drafting is being done on computers, but designs are becoming more complex involving more time. Generally, the existing employees will fill the same positions, but do more.

Engineering technicians and technologists could be better utilized. Their academic training has prepared them to understand and adapt the new technology and made them attractive candidates for management. Some employers note that they are beginning to employ more technologists than engineers and that this is the optimal approach for the future.

4.2 A Scenario

Computers and EDP based systems will expand their presence in manufacturing, design and information management. By the mid 1990's, the major re-adjustment will be complete. Surviving businesses will be highly automated. CAD/CAM methods will be in wide use. New management philosophies focussed on equipment analyis, quality control and efficiency will be in place. Business will expect access from their desk-top PC to a broad range of information located in databases around the world.

Increasingly, judgement based on knowledge and experience will become the most critical input. Managers may not have the ability or the experience to provide this, so reliance on technically skilled people will increase. Unskilled workers will not be the ones to fill this role. The knowledge of the world will be available in every workplace at every workstation. The challenge will be to use that power accurately, safely and cost effectively and that means through technical personnel.

f) Occupation specific recommendations require a detailed supply and demand study. This is beyond the scope of this project. However, a number of general recommendations can be made.

Increased amounts of hands-on experience in programming and user-friendly applications are clearly beneficial to personnel in all occupations dealing with technology and micro-electronic equipment.

Broadly based technical literacy is apparently as important as specific technological skills. Most employers tend to train on-the-job to meet specific skill needs. Thus, increased specialization as a general rule is not recommended. Education should concentrate on acquiring basic skill sets upon which specific workplace skills will be based.

g) The employment trends which are developing concerning engineering technicians and technologists suggest that the COPS fixed coefficient demand projections should receive careful evaluation. The views of those interviewed all suggest emerging structural change based on EDP technology will occur over the next few years.

The MANSCETT database presents a unique opportunity to understand the nature of employment among MANSCETT members. Initially, a snapshot taken in December, 1986 is available. Continuing surveys on an annual basis will generate a longitudinal database in which employment trends can be mapped and assessed. The findings will assist MANSCETT to evaluate the membership skills and compare these skills with employer needs.

The current database should be used to evaluate and consider:

- Emerging occupations (where are younger members employed but older members not?)
- Declining occupations (what do older members do that more recent graduates do not?)
- Where are the centres of technology located (industry sector, geographic location, size of firm, etc)
- What is the educational background of the membership? Is it increasing? In what fields?
- Do specific educational backgrounds lead to better job opportunities and career growth? That is, in what sectors and at what level of responsibility are graduates of specific programs found and how long after graduation?

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4.3 Implications for Employment

The demands of the future are increasingly related to the effective use of micro-electronics. This brings with it the need for more people with more advanced technical skills in areas such as electronics maintenance and service, software skills and control theory. Essentially, the need is for more technically trained personnel who can integrate electronics with design, operations and quality control.

CAD/CAM is becoming more prevalent in even very small organizations as more capability can be had for less cost. This allows technicians and technologists to extend their workplace from the design activity through the entire manufacturing process. The PC is changing the functioning of the office environment. Entirely new products are emerging based on micro-electronics.

The net effect is to require more highly trained personnel. Manual skills are being replaced with brainpower. The emphasis on mechanical devices is being displaced by reliance on micro-processors. Mechanical tradespeople and machinists are replaced by electronics technicians and programmers.

Surveys of companies involved in the manufacture of electronics report that few expect to increase employment, but all expect to rapidly increase output. The implication is that the gains will be achieved through the expanded use of micro-processors and a more capital (and technologically) intensive workplace.

Drafting, surveying, drawing, assembler language programming and mechanical skills are all becoming redundant. However, skills in using CAD, computer modelling, numerical analysis, programming, are becoming more important.

> "The transformation is ... a fundamental and far-reaching one. We are moving from manufacturing to services, from hardware to thoughtware, from large scale capital-intensive companies to smaller-scale labor-intensive companies, and from a dependence on physical capital to a dependence on human capital."
>
> David L. Birch
> The Public Interest
> No. 65, Fall 1981

5. CONCLUSIONS

A review of the data presented in the previous pages of this document shows a remarkable consensus between sectors and throughout the country. Virtually all conclusions apply to Canada at large and to Manitoba. The nature of the technology is breaking down historical differences between regions and industries. The technology is becoming global and the impacts are being felt around the world.

> "The industrial revolution took two centuries to recast society and alter the way people worked, culminating in 96 percent of the population in advanced countries working in factories, in offices and in the home - all fed by the 4 percent left working on the land. ...over the coming five years, four out of five people in the industrial world will be doing jobs differently from the way they have been done in the previous 50 years. The difficulty is that the half life of people's knowledge is contracting so fast that it now almost equals the time taken to acquire it."
>
> The Economist

5.1 Surpluses and Shortages

All those interviewed seemed to feel that they could find adequate numbers of staff with adequate skills to do the job. Most feel that there is a need for on-the-job and continuing education training opportunities. The major findings are summarized below:

a) Micro-electronic processors are replacing mechanical techniques. Result is the elimination of moderately skilled machinists and draftspersons by more highly skilled engineering technicians and technologists.

b) Conventional draftspersons and traditional surveying skills will be in less and less demand. Both these occupations have been changed dramatically by the application of EDP technology. Increasingly, surveying is accomplished through remote sensing and digitized conversion to a finished product. Conventional drafting is accomplished by the designer using a CAD station with the drawings themselves produced without manual intervention. Some shops operate two shifts of design activity with the third shift allocated to the production of drawings under supervision of a computer operator.

c) Key shortages related to EDP applications are expected to be for programmers, technicians and engineers. These are knowledge based occupations as opposed to mechanical skill based positions.

d) The number of high-tech jobs created will not likely offset the overall decline in manufacturing employment. However, the number of professional and technical employees WILL expand.

5.2 Training

The major implications of EDP technology are with respect to training.

a) Most people will have to go back to school or otherwise retrain.

b) There will be a need to learn systems, especially management and maintenance systems such as:

Decision support systems
Sophisticated modelling and control systems
On-line management information systems
Computerized monitoring and control of production processes
CAD/CAM design systems

c) Specific skills will be acquired on the job but CAD skills should be injected into basic training programs.

d) Actual drawing board practise should be replaced with EDP CAD/CAM training.

e) Keyboarding should become a part of the basic educational system. If not available in public schools, it should be mandatory for post-secondary courses related to electronics or their use.

f) The need for mathematics skills increases as sophistication in equipment grows. Techniques such as Statistical Process Control (SPC) requires better mathematical comprehension. The ability to program computers is important.

g) "The (automotive) industry will require new workers ... to have higher basic literacy and levels of mathematical skills and would prefer more applied science as well." (p.162, Ref 8).

h) Micro-processors increase the complexity associated with maintenance activities. More advanced skills are needed to deal with electronics. Typically, skill upgrading is necessary to deal with ever more complex and advanced equipment. In time, this may settle out as built-in diagnostics become more sophisticated reducing the demands on service personnel.

i) "Theoretical insight and imagination will be the keys ..." Shoshana Zuboff.

j) Basic language skills are important to employers. Many noted that language capabilities (especially written work) must be more highly developed to ensure communications are accurate and meaningful.

6. RECOMMENDATIONS FOR FURTHER STUDY AND ANALYSIS

The study brought out several areas where further work may be warranted. DALCOR presents some of the overview considerations in the form of recommendations. It is acknowledged that MANSCETT has taken some steps already, but where this is the case, more broadly based programs would still be beneficial. Clearly technological change is of special importance to technicians and technologists. It should lead to increased opportunities, but it is up to MANSCETT to ensure these opportunities are realized by its members.

MANSCETT can assist its members to adapt and also demonstrate its commitment to employers by carrying out a number of programs. The recommendations set out below are based on the findings obtained from a review of the literature, from a telephone survey program and through personal interviews.

a) MANSCETT needs to expand its public relations efforts to convince more employers of the value of certification. This may be in the form of seminars for employers or the development of formalized continuing education programs for the membership.

b) Over response to current perceptions of shortages should be cautioned. Technology and human resource requirements have a tendency to inter-react and personnel problems to self-correct over time. What is clear is that the nature of emerging demands must be considered by MANSCETT, educators and by employers in continuing education opportunities.

c) Increased emphasis on language skills would be beneficial. MANSCETT does require one year of experience in Canada plus a technical thesis and two exams for certification. However, a number of those we contacted during the survey had difficulty understanding what we were talking about.

d) Major employers welcome MANSCETT's cooperative programs and activities to upgrade existing personnel. The Manitoba Hydro and City of Winnipeg programs are paying dividends. Such programs and activities should be expanded to other employers. This would also improve their perception of MANSCETT and its objectives and lead to increased numbers of members.

e) The need for a productivity based labour market projection model is clearly evident. The current COPS fixed coefficient model is inappropriate for analysis related to technological change. Present moves by COPS to enhance their approach and deal with such issues should be encouraged (see "g" below).

APPENDIX A

LIST OF ORGANIZATIONS CONTACTED

FIRM SIZE	ORGANIZATION NAME	TECHS EMPLOYED (reported)	CONTACT
A	Manitoba Hydro	300-350	Doug Chapman Mgr Trans Plng.
A	Manitoba Telephones	650 (E)	Larry Sopko Project Manager
C	Red River Community College	100 (E)	Harold Wilson Head Mech Technology
A	City of Winnipeg	50	Ted Clarke Dir Street & Traff
C	W L Wardrop & Assoc	20	D. Grimes President
B	Bristol Aerospace LTD	100	Ralph Bullock Vice-President
A	University of Manitoba	50	Glenn Morris Assoc Dean of Eng
A	Atomic Energy Canada Ltd.	250	Dave Fisher Personnel Mgr.
A	Province of Manitoba	300	Kelly Kjartanson Environment Eng
A	Honeywell LTD	7	Emmanuel Bettancourt CET
A	Boeing of Canada LTD	20	Derek Woolley Chief Engineer
A	Hudson Bay Mining and Smelting	200	R.G. Sigismund Chief Engineer
A	INCO Metals	45	John Fulton Engineer
C	Ducks Unlimited	25	Ron Coley Chief Engineer
B	Flyer Industries	0	Tony Plante Manager Labour
B	UMA Group	50	R. Hood VP & Manitoba Mgr

ESTIMATED FIRM SIZE

A >1000 Employees
B 500 - 999 Employees
C 100 - 499 Employees
D < 100 Employees
(E) ....., ESTIMATE

KEY QUESTIONS RE TECHNOLOGICAL CHANGE

ORGANIZATION _____

ADDRESS _____

TELEPHONE _____

CONTACT _____ TITLE _____

INFO RE RESPONDENT AGE (Approx) _____ (ie 30, 40, 50 ?)

SEX _____

LEVEL of EDUC _____ (Univ, Tech, Other)

How many Techs/technol employed in organization _____ estimate

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QUESTIONS

1. How would you rate yourself on a computer expertise scale?

No knowledge									State of the art
1	2	3	4	5	6	7	8	9	10
Responses: 0	1	5	1	0	3	2	2	1	1

2. Have you ever written a computer program with a technical application?
   Yes - 9
   No - 7

3. Have you ever used a computer and computer program to do a technical job?
   Yes - 10
   No - 6

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4. Rate the following statements on a scale of 1 to 5

   A. Computer software and hardware will continue to increase rapidly over the next 10 to 20 years.

   Strongly Agree - 9
   Agree - 5
   Neutral - 0
   Disagree - 1
   Strongly Disagree - 1

B. By the year 2000, computers will actually do most of the work now done by technicians and technologists.

Strongly Agree	- 0
Agree	- 1
Neutral	- 4
Disagree	- 10
Strongly Disagree	- 1

C. Between now and 2000, computers will reduce the number of technicians and technologists needed per 1000 population (or per $ million of GDP - Gross Domestic Product) unless new roles are developed.

Strongly Agree	- 0
Agree	- 5
Neutral	- 2
Disagree	- 6
Strongly Disagree	- 3

D. I think there will be fewer technical support people. Engineers will each have a computer terminal and access to data bases, plotters, printers, design drawing apparatus, etc. The engineering team may well be an engineer and a computer.

Strongly Agree	- 0
Agree	- 2
Neutral	- 2
Disagree	- 7
Strongly Disagree	- 5

E. Computers will not change much of anything except to improve the quality of technical work from what it is now.

Strongly Agree	- 0
Agree	- 9
Neutral	- 1
Disagree	- 4
Strongly Disagree	- 2

F. Technicians and technologists will need just as good an understanding of the principles of math and science and related subjects as those graduating today -- even if computers become more highly sophisticated.

Strongly Agree	- 7
Agree	- 7
Neutral	- 1
Disagree	- 0
Strongly Disagree	- 1

G. By 2000, people with not much more training than computer-use skills will be able to use computers and computer programs and get satisfactory technical results from proven programs without knowing how the programs work, why they work nor the priciples of math, science and applied science which have been applied by the program writers.

Strongly Agree - 1
Agree - 7
Neutral - 2
Disagree - 3
Strongly Disagree - 3

H. Even if "G" is true, certification by MANSCETT and educational programs should require a solid understanding of math, science and applied subjects.

Strongly Agree - 9
Agree - 6
Neutral - 0
Disagree - 1
Strongly Disagree - 0

I. By 2000, technicians and technologists who are not able to use computers will have been left behind by the marketplace.

Strongly Agree - 9
Agree - 7
Neutral - 0
Disagree - 0
Strongly Disagree - 0

J. Governments should give top priority to funding business and educational facilities to stimulate training and upgrading efforts aimed at technicians and technologists.

Strongly Agree - 2
Agree - 9
Neutral - 2
Disagree - 2
Strongly Disagree - 1

K. Computers will be used more by technologists than by engineers. The effects will be greater on technologists than engineers.

Strongly Agree - 0
Agree - 2
Neutral - 3
Disagree - 10
Strongly Disagree - 1

L. Computers will never DO technology. They will just help technicuians and technologists to do their work better: not faster, just better.

Strongly Agree	- 1
Agree	- 5
Neutral	- 1
Disagree	- 7
Strongly Disagree	- 2

5. Are there any activities which you think computers WILL NOT be able to do?

- Field work. i.e. traffic counts
- Computers can't make judgement/evaluations
- Can be used as a tool only
- Machine drawings - one time drawings

6. What subjects should future technicians and technologists learn which they have not up to this time?

- Writing and communication skills/humanities
- Hydrology, (structural) hydraulics, soils
- Keyboarding
- Computer training i.e. CAD/CAM

7. what subjects will future technicians and technologists not learn which they do study now?

- Certain things will become obsolete within subjects, material may be reduced to allow room for new technology. As time goes on there will be an "overload" so there should be emphasis on learning how to access information more than memorizing it.
- Hours of drafting training could be reduced.

8. Can you identify any activities which are done by technicians and technologists that are or could be done by a relatively unskilled computer operator and a good quality computer and computer program?

- Manufacturing Industry - testing products/inspections using given criteria, reduce work in process time/throughput higher.
- Survey data
- Drafting - CAD/CAM
- Numerical control, plant layout, duct design.
- Routine mine calculations

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9. Assuming that computers will be a very time-saving tool for technicians and technologists, what NEW activities might these people take on?

   - Broaden scope into management/accounting.
   - Most people are saying there won't be time for new activities if jobs are being done properly/engineering field is expanding.

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